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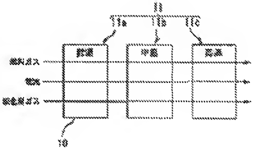
(54) FUEL CELL SYSTEM

(57)Abstract:

PROBLEM TO BE SOLVED: To accelerate reaction and increasing the battery cell output by successively relatively raising the operation temperature of cell stacks connected in series in the flow direction of reaction gas, and moistening the reaction gas according to the operating temperature of the cell stack flowing at first, then supplying the moistened reaction gas.



SOLUTION: A fuel cell system is constituted with cell stacks 11a, 11b, 11c for operating at low, middle, and high temperatures, fuel gas and oxidizing agent gas let continuously flow from the low temperature side to the high temperature side. The fuel gas and the oxidizing agent gas are previously moistened by adding water vapor, and the temperature of a reaction gas is raised so as to correspond to the operation temperature of each cell stack. Even if the non-reacted part of the reaction gas is increased in the cell stack 11a for operating at low temperature, the non-reacted gas is reacted and completely consumed in the cell stacks 11b, 11c for operating at the intermediate and high temperatures. Even if condensed water generating on a carbon electrode side of the cell stack 11a is increased, the water is evaporated in the cell stacks

11b, 11c, and the reaction of the oxidizing agent gas is conducted smoothly.

CLAIMS

[Claim(s)]

[Claim 1]A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, A fuel cell device humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first.

[Claim 2]A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, A fuel cell device equipping a flow direction and a uniform direction of said reactant gas with a cooling-medium feeding means which pours a cooling medium while humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first.

[Claim 3]The fuel cell device according to claim 1 or 2 dividing a cell stack linked to series one by one along a flow direction of reactant gas to each cell stack an object for low-temperature operation, for moderate temperature operation, and for high temperature operations.

[Claim 4]A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at

a cell stack linked to these series, Said at least one or more cell stacks which carried out the temperature rise relatively one by one, A fuel cell device humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a sub cell stack passed first while dividing to a sub cell stack which carried out the temperature rise still more relatively [one by one] to a flow direction of said reactant gas.

[Claim 5]The fuel cell device according to claim 4 dividing a sub cell stack which divided at least one or more cell stacks one by one along a flow direction of reactant gas to an object for low-temperature operation, an object for moderate temperature operation, and each sub cell stack for high temperature operations.

[Claim 6]The fuel cell device according to claim 1, 2, or 4 forming relatively small an effective area product of the downstream of a reactant gas supply groove formed in a separator compared with an effective area product of the upstream of said reactant gas supply groove.

[Claim 7]A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, A fuel cell device having a means which flows through said reactant gas passed to said cell stack which carried out the temperature rise relatively one by one in any direction for Masakata and of an opposite direction while humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first.

[Claim 8]A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, Said at least one or more cell stacks which carried out the temperature rise relatively one by one, It divides to a sub cell stack which carried out the temperature rise still more relatively [one by one] to a flow direction of said reactant gas, A fuel cell device equipping a flow direction and a uniform direction of said reactant gas with a cooling-medium feeding means which pours a cooling medium in series while humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a sub cell stack passed first.

[Claim 9]A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, A fuel cell device equipping with a

header both sides of a reactant gas supply groove formed in said separator in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series.
[Claim 10]The fuel cell device according to claim 9 equipping a pars basilaris ossis occipitalis of a header with a manifold.
[Claim 11]On both sides of solid polyelectrolyte membrane characterized by comprising the following, on both sides. A fuel cell device which supplies reactant gas to a cell stack which connected to series a cell stack which accumulated and constituted a unit cell provided with a separator in which an anode electrode and a cathode terminal were made to infix, and was connected to these series at series.
A means to make reactant gas supplied to said first cell stack humidify while carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [, one by one] to a flow direction of said reactant gas.
A cooling-medium feed unit which makes a cell stack which was connected to said series and carried out the temperature rise relatively one by one circulate through a cooling medium.
A control system which drives a cooling-medium feed unit which makes a cell stack which was connected to said series and carried out the temperature rise relatively one by one circulate through a cooling medium.

[Claim 12]The fuel cell device according to claim 11 constituting a cooling-medium feed unit combining a condensator, a tank, and a circulating pump.
[Claim 13]The fuel cell device comprising according to claim 11:
A signal of either one of the dew-point temperature of a cell stack, and humidity which connected with series and carried out the temperature rise of the operating temperature to a control system relatively one by one in a flow direction of reactant gas.
A control calculation part which drives or stops a cooling-medium feed unit which calculates based on a vessel internal temperature degree signal of said electric stack, and supplies a cooling medium to said cell stack.

[Claim 14]The fuel cell device comprising according to claim 11:
A signal of an internal resistance value of a unit cell which constitutes a cell stack which connected with series and carried out the temperature rise of the operating temperature to a control system relatively [one by one] to a flow direction of reactant gas.
A control calculation part which drives or stops a cooling-medium feed unit which calculates based on a vessel internal temperature degree signal of said cell stack, and supplies a cooling medium to said cell stack.

[Claim 15]It calculates based on a current signal and a vessel internal temperature degree

signal which are generated in a cell stack which connected with a humidity signal of reactant gas, and series, and carried out the temperature rise of the operating temperature to a control system relatively [one by one] to a flow direction of reactant gas, The fuel cell device according to claim 11 provided with a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the fuel cell device using the solid polymer membrane provided with ion conductivity as an electrolyte.
[0002]
[Description of the Prior Art]There is a thing of some form in a fuel cell device according to an electrolytic kind. In respect of the solid polymer electrolytic type fuel cell device using the solid polymer membrane provided with ion conductor nature as an electrolyte having high power density, and being able to make structure compact comparatively also in these, etc., it is observed these days and there are some which are shown in drawing 10 as the composition.
[0003]While this solid polyelectrolyte type fuel cell device constitutes the unit cell (unit cell) 4 which equipped both sides with the anode electrode (fuel electrode) 2 and the cathode terminal (oxidizing agent pole) 3 on both sides of the solid polyelectrolyte membrane 1 arranged in that center, It has the fuel gas supply groove 5a and the oxidant gas supply groove 5b which divide into each electrodes 2 and 3 and supply each of oxygen in fuel gas, for example, hydrogen, and oxidant gas, for example, air, via 6a and 7a, and has the composition of having excelled in conductivity and having formed the impermeable separators 6 and 7.
[0004]The anode electrode 2 is formed with the anode catalyst layer 2a and anode porous carbon monotonous 2b.
On the other hand, the cathode terminal 3 is formed with the cathode catalyst bed 3a and the cathode porous carbon plate 3b.

[0005]In the solid polyelectrolyte type fuel cell device provided with such composition, if fuel gas is supplied to the anode electrode 2 side and oxidant gas is supplied to the cathode terminal 3 side, the chemical reaction of the unit cell 4 will be carried out, and it will generate

current. That is, if fuel gas is supplied to the anode electrode 2 side, while passing the hydrogen ion which was made to divide fuel gas into a hydrogen ion and an electron, and was separated to the solid polymer membrane 1, the anode catalyst layer 2a will pour an electron to an external circuit (not shown), and will generate current.

[0006]If oxidant gas is supplied to the cathode terminal 3 side, the cathode catalyst bed 3a will make the electron from the above-mentioned hydrogen ion and external circuit from the solid polyelectrolyte membrane 1 react to oxidant gas, especially oxygen, and will generate the water of condensation. In that case, the chemical equation by the side of the anode electrode 2 and the cathode terminal 3 is expressed with a following formula, respectively.

[0007]

[Formula 1]

アノード[illegible] : $H_2 \rightarrow 2H^+ + 2e^-$

カソード[illegible] : $2H^+ + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O$

[0008]The water of condensation generated by the cathode terminal 3 side is emitted out of a vessel from the unit cell 4 with a unconverted gas.

[0009]Thus, although the unit cell 4 makes fuel gas and oxidant gas react and is generating electromotive force, since the electromotive force to generate is less than 1V, usually it makes the unit cell 4 tens - 100 numbers, accumulates it in the perpendicular direction, and constitutes the cell stack 8 from a solid polyelectrolyte type fuel cell device.

[0010]The park RUORORO carbon sulfonic acid (trade name: Nafion, the U.S. Du Pont make) which, on the other hand, produces the solid polyelectrolyte membrane 1 applied as an electrolyte, for example to proton exchange membrane is used. This solid polyelectrolyte membrane 1 has an exchange group of a hydrogen ion in a molecule, and has a function good as ion conductivity by holding saturated water.

[0011]By the way, in order to generate the still higher electromotive force from the cell stack 8 and to secure good ion conductivity conjointly with development of the solid polymer membrane 1, making saturated water always hold is needed for the solid polyelectrolyte membrane 1. If the water of condensation generated by the cathode terminal 3 side is neglected as it is, since the reaction of the cathode terminal 3 will worsen, removal of the water of condensation is needed.

[0012]In order to make saturated water always hold to the solid polyelectrolyte membrane 1, if the steam near operational status is beforehand added to reactant gas (both fuel gas and oxidant gas) and is humidified, even if easily solvable, that structure is also complicated helps a means to remove the water of condensation generated at the cathode terminal 3 side, and development is difficult and is groping for it now.

[0013]
[Problem(s) to be Solved by the Invention]These days as a means to remove the water of condensation generated at the cathode terminal 3 side, Form the fuel gas supply groove 5a and the oxidant gas supply groove 5b of the separators 6 and 7 which supply reactant gas in the shape of Serpentine, or. The effective area product of the fuel gas supply groove 5a and the oxidant gas supply groove 5b is made small, a gas flow rate is raised, and the invention which blows away the water of condensation besides a vessel using the velocity energy is released (U.S. patent USP-4,988,583, USP-5,108,849).
[0014]However, in order to raise a gas flow rate, when the effective area product of the fuel gas supply groove 5a of the separators 6 and 7 and the oxidant gas supply groove 5b was made small, the number of each slots 5a and 5b increased further, the production man day also increased, and there was a problem that the cost which produces the cell stack 8 became much more expensive.
[0015]The water of condensation collected in each of that slot 5a and 5b when the effective area product of the fuel gas supply groove 5a of the separators 6 and 7 and the oxidant gas supply groove 5b was made small, Even if it could blow away besides the vessel, the water of condensation generated by the cathode catalyst bed 3a needed to be again put back to each of those slots 5a and 5b via the cathode porous carbon plate 3b, and there was a problem that the water of condensation was certainly unremovable only by raising a gas flow rate.
[0016]In order to blow away besides a vessel the water of condensation brought together in the fuel gas supply groove 5a and the oxidant gas supply groove 5b, Reactant gas needed to be high-voltage-ized, only the part which made reactant gas high-voltage-ize consumed many energies, and there were fault, such as becoming a factor which reduces plant thermal efficiency rather, and inconvenience on a sankey diagram as a result.
[0017]When the fuel gas supply groove 5a and the oxidant gas supply groove 5b were formed in the shape of Serpentine, there was a problem that the pressure loss of reactant gas made increase and consequential more much reactant gas consume.
[0018]An object of this invention is to provide the fuel cell device which coped with such a problem, was made, made the water of condensation generated by the cathode terminal side remove certainly, promoted the reaction of fuel gas and oxidant gas further, and attained high cell output-ization.
[0019]
[Means for Solving the Problem]To achieve the above objects, as indicated to claim 1, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series

relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, Corresponding to an operating temperature of a cell stack passed first, said reactant gas is humidified beforehand and supplied.

[0020]To achieve the above objects, as indicated to claim 2, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, While humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first, a flow direction and a uniform direction of said reactant gas are equipped with a cooling-medium feeding means which pours a cooling medium.

[0021]To achieve the above objects, a fuel cell device concerning this invention divides a cell stack linked to series one by one along a flow direction of reactant gas to each cell stack an object for low-temperature operation, for moderate temperature operation, and for high temperature operations, as indicated to claim 3.

[0022]To achieve the above objects, as indicated to claim 4, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, While dividing said at least one or more cell stacks which carried out the temperature rise relatively one by one to a sub cell stack which carried out the temperature rise still more relatively [one by one] to a flow direction of said reactant gas, corresponding to an operating temperature of a sub cell stack passed first, said reactant gas is humidified beforehand and supplied.

[0023]To achieve the above objects, as indicated to claim 5, a fuel cell device concerning this invention, A sub cell stack which divided at least one or more cell stacks is divided one by one along a flow direction of reactant gas to an object for low-temperature operation, an object for moderate temperature operation, and each sub cell stack for high temperature operations.

[0024]To achieve the above objects, a fuel cell device concerning this invention forms relatively small an effective area product of the downstream of a reactant gas supply groove formed in a separator compared with an effective area product of the upstream of said reactant gas supply groove, as indicated to claim 6.

[0025]To achieve the above objects, as indicated to claim 7, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, While humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first, it has a means which flows through said reactant gas passed to said cell stack which carried out the temperature rise relatively one by one in any direction for Masakata and of an opposite direction.

[0026]To achieve the above objects, as indicated to claim 8, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, Said at least one or more cell stacks which carried out the temperature rise relatively one by one. It divides to a sub cell stack which carried out the temperature rise still more relatively [one by one] to a flow direction of said reactant gas, While humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a sub cell stack passed first, a flow direction and a uniform direction of said reactant gas are equipped with a cooling-medium feeding means which pours a cooling medium in series.

[0027]To achieve the above objects, as indicated to claim 9, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, In a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, both sides of a reactant gas supply groove formed in said separator are equipped with a header.

[0028]To achieve the above objects, a fuel cell device concerning this invention equips a pars basilaris ossis occipitalis of a header with a manifold, as indicated to claim 10.

[0029]To achieve the above objects, as indicated to claim 11, a fuel cell device of this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, In a fuel cell device which supplies reactant gas to a cell stack linked to these series at series, it is characterized by comprising

the following:
A means to make reactant gas supplied to said first cell stack humidify while carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [, one by one] to a flow direction of said reactant gas.
A cooling-medium feed unit which makes a cell stack which was connected to said series and carried out the temperature rise relatively one by one circulate through a cooling medium.
A control system which drives a cooling-medium feed unit which makes a cell stack which was connected to said series and carried out the temperature rise relatively one by one circulate through a cooling medium.

[0030]To achieve the above objects, a fuel cell device concerning this invention constitutes a cooling-medium feed unit combining a condensator, a tank, and a circulating pump, as indicated to claim 12.
[0031]To achieve the above objects, as indicated to claim 13, a fuel cell device concerning this invention, A signal of either one of the dew-point temperature of a cell stack, and humidity which connected with series and carried out the temperature rise of the operating temperature to a control system relatively one by one in a flow direction of reactant gas, It calculates based on a vessel internal temperature degree signal of said electric stack, and has a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.
[0032]To achieve the above objects, as indicated to claim 14, a fuel cell device concerning this invention, A signal of an internal resistance value of a unit cell which constitutes a cell stack which connected with series and carried out the temperature rise of the operating temperature to a control system relatively [one by one] to a flow direction of reactant gas, It calculates based on a vessel internal temperature degree signal of said cell stack, and has a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.
[0033]To achieve the above objects, as indicated to claim 15, a fuel cell device concerning this invention, It calculates based on a current signal and a vessel internal temperature degree signal which are generated in a cell stack which connected with a humidity signal of reactant gas, and series, and carried out the temperature rise of the operating temperature to a control system relatively [one by one] to a flow direction of reactant gas, It has a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.
[0034]
[Embodiment of the Invention]Hereafter, the embodiment of the fuel cell device concerning this invention is described using the numerals attached in the drawing and the figure.

[0035]Drawing 1 is a mimetic diagram showing a 1st embodiment of the fuel cell device concerning this invention.

[0036]The fuel cell device concerning this embodiment the plate-like unit cell (unit cell) 10 which makes a usable area 169-cm^2, for example. Use ten sheets, put in the perpendicular direction, constitute the cell stack 11, and the cell stack 11. For example, while dividing to the cell stack 11a for low-temperature operation, the cell stack 11b for moderate temperature operation, and the cell stack 11c for high temperature operations and electrically connecting, It has composition which passes fuel gas and oxidant gas continuously toward the cell stack 11c for high temperature operations from the cell stack 11a for low-temperature operation among the cell stacks 11a, 11b, and 11c for high temperature operations into each low one. In this embodiment, each operating temperature of the cell stacks 11a, 11b, and 11 for high temperature operations is set as 50 **, 60 **, and 65 ** into low. A steam is beforehand added and humidified into low to the fuel gas and oxidant gas which are supplied to the cell stacks 11a, 11b, and 11c for high temperature operations, and into low, humidity of above-mentioned reactant gas is made high so that the operating temperature of the cell stacks 11a, 11b, and 11c for high temperature operations may be balanced.

[0037]When reactant gas (both fuel gas and oxidant gas) flows toward the cell stack 11c for high temperature operations one by one from the cell stack 11a for low-temperature operation. Since the diffusion rate of as opposed to [a reaction consumption rate (capacity factor) is high at the upstream, and a reaction consumption rate is low at the downstream, and] the anode electrode side of reactant gas and the cathode terminal side becomes low, in this embodiment. The effective area product of the fuel gas supply groove of the downstream and an oxidizer supply groove (not shown [both]) is relatively made small compared with it of the upstream, and it has the composition of raising the rate of flow of reactant gas and making reaction efficiency equalizing. Both a fuel gas supply groove and an oxidant gas supply groove make a pitch the same, and, specifically, have formed the depth ratio in 4:3:1 into low to the cell stacks 11a, 11b, and 11c for high temperature operations.

[0038]At this embodiment provided with such composition, as a result of being test operation, as for 400 mA/cm^2 and the reaction consumption rate (capacity factor) of fuel gas, 80%, the reaction consumption rate (capacity factor) of oxidant gas became 50%, and cell output operation time of load current density improved in 3000 hours compared with the former.

[0039]In this embodiment, since the cell stack 11 was divided into low to the cell stacks 11a, 11b, and 11c for high temperature operations, Compared with one cell stack which sets an operating temperature constant, average voltage increased 5% like before, and generating the stable cell output with little variation distribution moreover was accepted.

[0040]Thus, in this embodiment, the cell stack 11 is divided into low to each of the cell stacks 11a, 11b, and 11c for high temperature operations. Since reactant gas was made the

composition passed from the cell stack 11a for low-temperature operation to continuation toward the cell stack 11c for high temperature operations one by one while carrying out the series connection of the cell stacks 11a, 11b, and 11c for high temperature operations electrically into low [which was divided]. The stable cell output can be generated and the reaction consumption rate (capacity factor) of reactant gas can be raised further.

[0041]Namely, into low, to the cell stacks 11a, 11b, and 11c for high temperature operations, one by one, since reactant gas is passed to continuation, For example, even if the unreacted part of reactant gas increases comparatively in the cell stack 11a for low-temperature operation, it can be made to be able to react by the next object for moderate temperature operation or the cell stacks 11b and 11c for high temperature operations, and can be made to consume without the place which leaves reactant gas.

[0042]In this embodiment, since the effective area product of the fuel gas supply groove of the downstream and the oxidant gas supply groove was relatively made small compared with it of the upstream and the rate of flow of reactant gas was raised, equalization of reaction efficiency can be attained and the stable cell output can be generated.

[0043]Therefore, since the cell output stable even if it did not supply reactant gas to each of the cell stacks 11a, 11b, and 11c for high temperature operations superfluously into low can be promoted according to this embodiment, the amount of supply of reactant gas can be lessened compared with the former.

[0044]In this embodiment, since each operating temperature of the cell stacks 11a, 11b, and 11c for high temperature operations was made high one by one in accordance with the flow of reactant gas into low, Since it will be made to evaporate in the object for moderate temperature operation or the cell stacks 11b and 11c for high temperature operations of order with a high operating temperature even if the water of condensation generated increases in number in the case of the reaction of the oxidant gas by the side of the carbon electrodes of the cell stack 11a for low-temperature operation, oxidant gas can be made to react good. Into low, although it may install separately [each of the cell stacks 11a, 11b, and 11c for high temperature operations] independently, since a specific cell stack has possibility of a fault cell output when it installs separately independently, it is preferred to carry out a series connection electrically.

[0045]Drawing 2 is a mimetic diagram showing a 2nd embodiment of the fuel cell device concerning this invention. Identical codes are given to the portion which is the same as the component part of a 1st embodiment, or corresponds.

[0046]The fuel cell device concerning this embodiment like a 1st embodiment the cell stack 11. For example, while dividing into low to the cell stacks 11a, 1b, and 11c for high temperature operations and carrying out the series connection of the cell stacks 11a, 11b, and 11c for high temperature operations electrically into low, The cooling-medium feeding means 12 which supplies a cooling medium, for example, cooling water, succeeding the cell stacks 11a, 11b,

and 11c for high temperature operations, for example, cooling water piping, is established into low. The operating temperature of the cell stack 11a for low-temperature operation is determined by the temperature of the cooling medium supplied from the cooling-medium feeding means 12. The operating temperature of the cell stack 11c for high temperature operations measures the temperature of the cooling medium discharged from the cell stack 11c for high temperature operations, and is determined by adjusting the amount of cooling media. The mean temperature of the operating temperature of the cell stack 11a for low-temperature operation and the operating temperature of the cell stack 11c for high temperature operations is used for the operating temperature of the cell stack 11b for moderate temperature operation.

[0047]Thus, in this embodiment, the cooling-medium feeding means 12 which continues and supplies a cooling medium to the cell stacks 11a, 11b, and 11c for high temperature operations is established into low, Since much more temperature inclination-ization of the cell stacks 11a, 11b, and 11c for high temperature operations was attained into low, When making oxidant gas react temporarily by the cathode terminal side of the cell stack 11a for low-temperature operation, Even if the water of condensation generated increases in number, promotion of evaporation can be made to be able to ensure by the next object for moderate temperature operation or the cell stacks 11b and 11c for high temperature operations, and the cell output which raised much more reaction of oxidant gas and was stabilized can be generated.

[0048]Drawing 3 is a mimetic diagram showing a 3rd embodiment of the fuel cell device concerning this invention. Identical codes are given to the portion which is the same as the component part of a 1st embodiment, or corresponds.

[0049]The inside of low [which showed the fuel cell device concerning this embodiment by a 1st embodiment], inside, and the cell stacks 11a, 11b, and 11c for high temperature operations, While dividing further the cell stack 11a for low-temperature operation into low to each of sub cell stack $11a_1$ for high temperature operations, $11a_2$, and $11a_3$, The flow direction and uniform direction of reactant gas (both fuel gas and oxidant gas) are made to carry out the series connection of sub cell stack $11a_1$ for high temperature operations, $11a_2$, and the $11a_3$ into low. Inside the cell stacks 11b and 11c for high temperature operations like ****, It is divided by sub cell stack $11b_1$ for low-temperature operation, $11c_1$, sub cell stack $11b_2$ for moderate temperature operation, $11c_2$, sub cell stack $11b_3$ for high temperature operations, and $11c_3$.

[0050]Generally, the cell stack 11 has cell output density in the tendency which becomes high to the thing compared with the outlet side in which the reaction consumption rate (capacity factor) of reactant gas is [the entrance side] lower, when the independent cell 10 is taken for an example.

[0051]In this embodiment, are what noted such a point, and into low to every cell stack 11a and 11b for high temperature operations, and 11c. It divides finely into low to sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --.

[0052]Low [which was divided into low in this embodiment to every cell stack 11a and 11b for high temperature operations, and 11c], Inside, The fuel gas supply groove which supplies reactant gas (both fuel gas and oxidant gas) to sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --. And compared with the upstream, the downstream is relatively made small for the effective area product of an oxidant gas supply groove (not shown [both]), and it has the composition of raising the fluid of reactant gas and making reaction efficiency equalizing. Like a 1st embodiment, make a pitch the same and specifically [both] the depth ratio. It has formed in 4:3:1 into low to sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --.

[0053]Thus, in this embodiment into low to every cell stack 11a and 11b for high temperature operations, and 11c. Since it divided finely into low with sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --, The stable cell output without the unevenness from the cell stacks 11a, 11b, and 11c for high temperature operations can be generated into low.

[0054]In this embodiment, into low to every cell stack 11a and 11b for high temperature operations, and 11c. Since it divided finely into low with sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --, In the case of the reaction of oxidant gas, the water of condensation generated can be evaporated further and the reaction of oxidant gas can be promoted good.

[0055]In this embodiment, since the effective area product of the fuel gas supply groove of the downstream and the oxidant gas supply groove was relatively made small compared with it of the upstream and the rate of flow of reactant gas was raised, much more equalization of reaction high rate can be attained, and the stable cell output can be generated.

[0056]Drawing 4 is a mimetic diagram showing a 4th embodiment of the fuel cell device concerning this invention. Identical codes are given to the component part, the identical parts, or the corresponding portion of a 1st embodiment.

[0057]Like a 1st embodiment, while dividing the fuel cell device concerning this embodiment, for example into low to the cell stacks 11a, 11b, and 11c for high temperature operations, the cell stack 11, The reactant gas currently supplied to the cell stacks 11b and 11c for high temperature operations is made inside the composition which supplies an opposite direction one by one from the cell stack 11a for low-temperature operation after the operation-time

progress which was able to be defined beforehand. The valve (not shown) installed in piping is specifically changed, and it is carried out by passing reactant gas to the flow direction and opposite direction of a graphic display. The operating method passed to an opposite direction is applied also to a 3rd embodiment shown by drawing 3 after the operation-time progress which was able to define reactant gas beforehand.

[0058]Thus, in this embodiment, since reactant gas was made the composition passed to an opposite direction after the operation-time progress which was able to be defined beforehand, the fall of the battery characteristic of the cell stacks 11a, 11b, and 11c for high temperature operations can be low suppressed into low, and generating of the stable cell output can be maintained for a long time.

[0059]Drawing 5 is a mimetic diagram showing a 5th embodiment of the fuel cell device concerning this invention. Identical codes are given to the portion which is the same as the component part of a 1st embodiment, a 2nd embodiment, and a 3rd embodiment, or corresponds.

[0060]The fuel cell device concerning this embodiment is what combined a 2nd embodiment and a 3rd embodiment with a 1st embodiment. Into low, to every cell stack 11a and 11b for high temperature operations, and 11c Low, inside, While dividing sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --, the cooling feeding means 12 which pours a cooling medium is formed in the flow direction and uniform direction of reactant gas.

[0061]In this embodiment, thus, low, inside, Establish sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and the cooling-medium feeding means 12 of -- that continues and supplies a cooling medium to the flow direction and uniform direction of reactant gas, and Low, inside, Since sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and much more temperature inclination-ization of -- were attained, Evaporation of the water of condensation of each sub cell stack $11a_1$, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and -- generated by the carbon-electrodes side can be promoted further, and the stable cell output can be generated.

[0062]Drawing 6 is a schematic diagram showing the embodiment of the separator applied to the fuel cell device concerning this invention.

[0063]While the separator 13 concerning this embodiment forms two or more reactant gas supply grooves 14 which supply reactant gas in accordance with the perpendicular direction, The entrance head 15 provided with the inlet manifold 15a and the exit header 16 provided with the outlet manifolds 16a are formed in the both ends of the reactant gas supply groove 14.

[0064]Thus, in this embodiment, since the inlet header 15 and the exit header 16 are formed in the both ends of the reactant gas supply groove 14 of the separator 13 and more reactant gas is supplied to them, a still higher cell output can be generated compared with the former.
[0065]In this embodiment, since the both ends of the reactant gas supply groove 14 were equipped with the inlet header 15 and the exit header 16, More water of condensation generated from reactant gas can be processed, and without making the structure of the reactant gas supply groove 14, and shape complicate like before, the production man day time can be lessened and it can contribute to cost reduction. Since this embodiment equips the pars-basilaris-ossis-occipitalis side of the inlet header 15 and the exit header 16 with the manifolds 15a and 16a of the entrance and the exit, it can change the feeding-and-discarding exit of reactant gas freely.
[0066]Drawing 7 is an outline control system figure showing the embodiment which controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention. Identical codes are given to the component part and identical parts of a 1st embodiment.
[0067]The cell stack 11 concerning this embodiment has the composition of having made into 30 sheets the plate-like unit cell (unit cell) 10 which makes a usable area 169-cm^2, for example, and having accumulated it in the perpendicular direction.
[0068]This cell stack 11 is provided with the humidifiers 17a and 17b which make that entrance side humidify fuel gas and oxidant gas, and the dew point recorder 18 which measures the humidity of oxidant gas to that outlet side. A hygrometer may be sufficient as the dew point recorder 18.
[0069]In order that the cell stack 11 may adjust the operating temperature in the vessel, It has composition provided with the cooling-medium feed unit 22 which combined the condensator 19, the tank 20, and the circulating pump 21 which supply a cooling medium, for example, cooling water, and the control calculation part 23 which gives a control signal to the condensator 19 and the circulating pump 21.
[0070]When the operating temperature in a vessel is set, for example as 80 ** now in the cell stack 11 provided with such composition, When the temperature which the operating temperature in a vessel measured with the dew point recorder 18 rather than 80 ** in the circumference of lower becomes 78 ** or less, the control calculation part 23, It calculates based on the operating temperature in a vessel, and the measurement temperature of the dew point recorder 18, the operation signal is given to the condensator 19 and the circulating pump 21, and the condensator 19 and the circulating pump 21 are made to drive. When it becomes higher than the operation operating temperature in a vessel, the control calculation part 23 gives the operation signal to the condensator 19 and the circulating pump 21, and stops the drive of the condensator 19 and the circulating pump 21.

[0071]thus -- forming the cooling-medium feed unit 22 and the control calculation part 23 in the cell stack 11 in this embodiment -- vessel inside installation -- a law -- to an operating temperature at the time of lower "****". Since evaporation of the water of condensation generated within a vessel was promoted when the water of condensation generated within a vessel was promoted, on the contrary it exceeded to the setting-out operating temperature in a vessel, the cell output generated from the cell stack 11 can be further heightened compared with the former. Incidentally, according to the experiment, sag speed was able to be made low 1/3 or less compared with the conventional operating-temperature regularity.

[0072]Drawing 8 is a control system figure showing the 1st modification of the embodiment shown in drawing 7 that controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention.

[0073]While making it the same as that of the composition of the embodiment shown by drawing 7 in this example, Attach the measure resistance device 24 which measures the internal resistance of the unit cell 10 to the cell stack 11, it is made to calculate in the control calculation part 23 based on the resistance signal from the measure resistance device 24, and a vessel internal temperature degree signal, and is made to drive the cooling-medium feed unit 22.

[0074]When the measure resistance device 24 sets the operating temperature in a vessel, for example as 80 **, If the internal resistance value of the unit cell 10 becomes for example, more than 90-ohmcm^2, If the cooling-medium feed unit 22 is made to drive, the operating temperature of the cell stack 11 is reduced and it becomes below 90-ohmcm^2 conversely, the drive of the cooling-medium feed unit 22 is stopped, and it has composition which raises the operating temperature of the cell stack 11.

[0075]Therefore, according to this example, the cell output of the water of condensation generated in a vessel generated from the cell stack 11 since the operating temperature of the cell stack 11 is somewhat controllable according to quantity can be further heightened compared with the former.

[0076]Although the measure resistance device 24 was attached to the cell stack 11 in this example, Load current 25 [a total of] may be attached to the cell stack 11, it may be made to calculate in the control calculation part 23 based on the current signal from load current 25 [a total of], the signal from the humidifiers 17a and 17b, and the vessel internal temperature degree signal from the thermometer 26, and the cooling-medium feed unit 22 may be made to drive, as shown in drawing 9.

[0077]

[Effect of the Invention]The fuel cell device concerning this invention as the above explanation, While carrying out the temperature rise of the operating temperature of the cell stack which connected the cell stack to series and was connected to series relatively [one by one] to the

flow direction of reactant gas, Since reactant gas is beforehand humidified corresponding to the operating temperature of the cell stack passed first, the reaction consumption rate of reactant gas can be raised and the stable cell output can be generated.

[0078]While carrying out the temperature rise of the operating temperature of the cell stack which the fuel cell device concerning this invention connected the cell stack to series, and was connected to series relatively [one by one] to the flow direction of reactant gas, Since the flow direction and uniform direction of reactant gas were equipped with the cooling-medium feeding means which pours a cooling medium and temperature inclination-ization of each cell stack was attained while making reactant gas humidify beforehand corresponding to the operating temperature of the cell stack passed first, The cell output which promoted evaporation of the water of condensation generated and was stabilized can be generated in the case of the reaction of oxidant gas.

[0079]While carrying out the temperature rise of the operating temperature of the cell stack which the fuel cell device concerning this invention connected the cell stack to series, and was connected to series relatively [one by one] to the flow direction of reactant gas, While dividing at least one or more cell stacks which carried out the temperature rise relatively one by one to the sub cell stack which carried out the temperature rise still more relatively [one by one] to the flow direction of reactant gas, Since reactant gas is beforehand humidified corresponding to the operating temperature of the sub cell stack passed first, the reaction consumption rate of reactant gas can be raised further, and the stable cell output can be generated.

[0080]While carrying out the temperature rise of the operating temperature of the cell stack which the fuel cell device concerning this invention connected the cell stack to series, and was connected to series relatively [one by one] to the flow direction of reactant gas, Since the reactant gas passed to the cell stack which carried out the temperature rise was made the composition which can be passed in any direction of right reverse, generating of the stable cell output can be maintained for a long time.

[0081]Since the fuel cell device concerning this invention was made the composition which provides a header in the both ends of a separate reactant gas supply groove, and can supply more reactant gas, it can generate a still higher cell output under the structure made to simplify.

[0082]Since the fuel cell device concerning this invention established the control system which controls the cooling-medium feed unit which adjusts the operating temperature of a cell stack, and a cooling-medium feed unit, it can be adjusted to the desirable amount of water which made the water of condensation generated by the cell stack correspond to operational status.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention]This invention relates to the fuel cell device using the solid polymer membrane provided with ion conductivity as an electrolyte.

[Translation done.]

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PRIOR ART

[Description of the Prior Art]There is a thing of some form in a fuel cell device according to an electrolytic kind. In respect of the solid polymer electrolytic type fuel cell device using the solid polymer membrane provided with ion conductor nature as an electrolyte having high power density, and being able to make structure compact comparatively also in these, etc., it is observed these days and there are some which are shown in drawing 10 as the composition.
[0003]While this solid polyelectrolyte type fuel cell device constitutes the unit cell (unit cell) 4 which equipped both sides with the anode electrode (fuel electrode) 2 and the cathode terminal (oxidizing agent pole) 3 on both sides of the solid polyelectrolyte membrane 1 arranged in that center, It has the fuel gas supply groove 5a and the oxidant gas supply groove 5b which divide into each electrodes 2 and 3 and supply each of oxygen in fuel gas, for example, hydrogen, and oxidant gas, for example, air, via 6a and 7a, and has the composition of having excelled in conductivity and having formed the impermeable separators 6 and 7.
[0004]The anode electrode 2 is formed with the anode catalyst layer 2a and anode porous carbon monotonous 2b.
On the other hand, the cathode terminal 3 is formed with the cathode catalyst bed 3a and the cathode porous carbon plate 3b.

[0005]In the solid polyelectrolyte type fuel cell device provided with such composition, if fuel gas is supplied to the anode electrode 2 side and oxidant gas is supplied to the cathode terminal 3 side, the chemical reaction of the unit cell 4 will be carried out, and it will generate current. That is, if fuel gas is supplied to the anode electrode 2 side, while passing the hydrogen ion which was made to divide fuel gas into a hydrogen ion and an electron, and was separated to the solid polymer membrane 1, the anode catalyst layer 2a will pour an electron to an external circuit (not shown), and will generate current.
[0006]If oxidant gas is supplied to the cathode terminal 3 side, the cathode catalyst bed 3a will

make the electron from the above-mentioned hydrogen ion and external circuit from the solid polyelectrolyte membrane 1 react to oxidant gas, especially oxygen, and will generate the water of condensation. In that case, the chemical equation by the side of the anode electrode 2 and the cathode terminal 3 is expressed with a following formula, respectively.

[0007]

[Formula 1]

アノード[illegible] : $H_2 \rightarrow 2H^+ + 2e^-$

カソード[illegible] : $2H^+ + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O$

[0008]The water of condensation generated by the cathode terminal 3 side is emitted out of a vessel from the unit cell 4 with a unconverted gas.

[0009]Thus, although the unit cell 4 makes fuel gas and oxidant gas react and is generating electromotive force, since electromotive force to generate is less than 1V, usually it makes the unit cell 4 tens - 100 numbers, accumulates it in the perpendicular direction, and constitutes the cell stack 8 from a solid polyelectrolyte type fuel cell device.

[0010]Park RUORORO carbon sulfonic acid (trade name: Nafion, the U.S. Du Pont make) which, on the other hand, produces the solid polyelectrolyte membrane 1 applied as an electrolyte, for example to proton exchange membrane is used. This solid polyelectrolyte membrane 1 has an exchange group of a hydrogen ion in a molecule, and has a function good as ion conductivity by holding saturated water.

[0011]By the way, in order to generate still higher electromotive force from the cell stack 8 and to secure good ion conductivity conjointly with development of the solid polymer membrane 1, making saturated water always hold is needed for the solid polyelectrolyte membrane 1. If the water of condensation generated by the cathode terminal 3 side is neglected as it is, since a reaction of the cathode terminal 3 will worsen, removal of the water of condensation is needed.

[0012]In order to make saturated water always hold to the solid polyelectrolyte membrane 1, if a steam near operational status is beforehand added to reactant gas (both fuel gas and oxidant gas) and is humidified, even if easily solvable, that structure is also complicated helps a means to remove the water of condensation generated at the cathode terminal 3 side, and development is difficult and is groping for it now.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention]The fuel cell device concerning this invention as the above explanation, While carrying out the temperature rise of the operating temperature of the cell stack which connected the cell stack to series and was connected to series relatively [one by one] to the flow direction of reactant gas, Since reactant gas is beforehand humidified corresponding to the operating temperature of the cell stack passed first, the reaction consumption rate of reactant gas can be raised and the stable cell output can be generated.
[0078]While carrying out the temperature rise of the operating temperature of the cell stack which the fuel cell device concerning this invention connected the cell stack to series, and was connected to series relatively [one by one] to the flow direction of reactant gas, reactant gas is made to humidify beforehand corresponding to the operating temperature of the cell stack passed first.
Since the flow direction and uniform direction of reactant gas were equipped with the cooling-medium feeding means which pours a cooling medium on the other hand and temperature inclination-ization of each cell stack was attained, the cell output which promoted evaporation of the water of condensation generated and was stabilized can be generated in the case of the reaction of oxidant gas.

[0079]While carrying out the temperature rise of the operating temperature of the cell stack which the fuel cell device concerning this invention connected the cell stack to series, and was connected to series relatively [one by one] to the flow direction of reactant gas, At least one or more cell stacks which carried out the temperature rise relatively one by one are divided to the sub cell stack which carried out the temperature rise still more relatively [one by one] to the flow direction of reactant gas.
On the other hand, since reactant gas is beforehand humidified corresponding to the operating temperature of the sub cell stack passed first, the reaction consumption rate of reactant gas

can be raised further, and the stable cell output can be generated.

[0080]While carrying out the temperature rise of the operating temperature of the cell stack which the fuel cell device concerning this invention connected the cell stack to series, and was connected to series relatively [one by one] to the flow direction of reactant gas, Since the reactant gas passed to the cell stack which carried out the temperature rise was made the composition which can be passed in any direction of right reverse, generating of the stable cell output can be maintained for a long time.

[0081]Since the fuel cell device concerning this invention was made the composition which provides a header in the both ends of a separate reactant gas supply groove, and can supply more reactant gas, it can generate a still higher cell output under the structure made to simplify.

[0082]Since the fuel cell device concerning this invention established the control system which controls the cooling-medium feed unit which adjusts the operating temperature of a cell stack, and a cooling-medium feed unit, it can be adjusted to the desirable amount of water which made the water of condensation generated by the cell stack correspond to operational status.

[Translation done.]

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MEANS

[Means for Solving the Problem]To achieve the above objects, as indicated to claim 1, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, Corresponding to an operating temperature of a cell stack passed first, said reactant gas is humidified beforehand and supplied.
[0020]To achieve the above objects, as indicated to claim 2, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, While humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first, a flow direction and a uniform direction of said reactant gas are equipped with a cooling-medium feeding means which pours a cooling medium.
[0021]To achieve the above objects, a fuel cell device concerning this invention divides a cell stack linked to series one by one along a flow direction of reactant gas to each cell stack an object for low-temperature operation, for moderate temperature operation, and for high temperature operations, as indicated to claim 3.
[0022]To achieve the above objects, as indicated to claim 4, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator

which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, While dividing said at least one or more cell stacks which carried out the temperature rise relatively one by one to a sub cell stack which carried out the temperature rise still more relatively [one by one] to a flow direction of said reactant gas, corresponding to an operating temperature of a sub cell stack passed first, said reactant gas is humidified beforehand and supplied.

[0023]To achieve the above objects, as indicated to claim 5, a fuel cell device concerning this invention, A sub cell stack which divided at least one or more cell stacks is divided one by one along a flow direction of reactant gas to an object for low-temperature operation, an object for moderate temperature operation, and each sub cell stack for high temperature operations.

[0024]To achieve the above objects, a fuel cell device concerning this invention forms relatively small an effective area product of the downstream of a reactant gas supply groove formed in a separator compared with an effective area product of the upstream of said reactant gas supply groove, as indicated to claim 6.

[0025]To achieve the above objects, as indicated to claim 7, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, While humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a cell stack passed first, it has a means which flows through said reactant gas passed to said cell stack which carried out the temperature rise relatively one by one in any direction for Masakata and of an opposite direction.

[0026]To achieve the above objects, as indicated to claim 8, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, While carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [one by one] to a flow direction of said reactant gas in a fuel cell device which supplies reactant gas to series at a cell stack linked to these series. Said at least one or more cell stacks which carried out the temperature rise relatively one by one, It divides to a sub cell stack which carried out the temperature rise still more relatively [one by one] to a flow direction of said reactant gas,

While humidifying said reactant gas beforehand and supplying it corresponding to an operating temperature of a sub cell stack passed first, a flow direction and a uniform direction of said reactant gas are equipped with a cooling-medium feeding means which pours a cooling medium in series.
[0027]To achieve the above objects, as indicated to claim 9, a fuel cell device concerning this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, In a fuel cell device which supplies reactant gas to series at a cell stack linked to these series, both sides of a reactant gas supply groove formed in said separator are equipped with a header.
[0028]To achieve the above objects, a fuel cell device concerning this invention equips a pars basilaris ossis occipitalis of a header with a manifold, as indicated to claim 10.
[0029]To achieve the above objects, as indicated to claim 11, a fuel cell device of this invention, A cell stack which accumulated and constituted a unit cell provided with a separator which made an anode electrode and a cathode terminal infix in both sides on both sides of solid polyelectrolyte membrane is connected to series, In a fuel cell device which supplies reactant gas to a cell stack linked to these series at series, it is characterized by comprising the following:
A means to make reactant gas supplied to said first cell stack humidify while carrying out the temperature rise of the operating temperature of a cell stack linked to said series relatively [, one by one] to a flow direction of said reactant gas.
A cooling-medium feed unit which makes a cell stack which was connected to said series and carried out the temperature rise relatively one by one circulate through a cooling medium.
A control system which drives a cooling-medium feed unit which makes a cell stack which was connected to said series and carried out the temperature rise relatively one by one circulate through a cooling medium.

[0030]To achieve the above objects, a fuel cell device concerning this invention constitutes a cooling-medium feed unit combining a condensator, a tank, and a circulating pump, as indicated to claim 12.
[0031]To achieve the above objects, as indicated to claim 13, a fuel cell device concerning this invention, A signal of either one of the dew-point temperature of a cell stack, and humidity which connected with series and carried out the temperature rise of the operating temperature to a control system relatively one by one in a flow direction of reactant gas, It calculates based on a vessel internal temperature degree signal of said electric stack, and has a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.

[0032]To achieve the above objects, as indicated to claim 14, a fuel cell device concerning this invention, A signal of an internal resistance value of a unit cell which constitutes a cell stack which connected with series and carried out the temperature rise of the operating temperature to a control system relatively [one by one] to a flow direction of reactant gas, It calculates based on a vessel internal temperature degree signal of said cell stack, and has a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.
[0033]To achieve the above objects, as indicated to claim 15, a fuel cell device concerning this invention, It calculates based on a current signal and a vessel internal temperature degree signal which are generated in a cell stack which connected with a humidity signal of reactant gas, and series, and carried out the temperature rise of the operating temperature to a control system relatively [one by one] to a flow direction of reactant gas, It has a control calculation part which drives or stops a cooling-medium feed unit which supplies a cooling medium to said cell stack.
[0034]
[Embodiment of the Invention]Hereafter, the embodiment of the fuel cell device concerning this invention is described using the numerals attached in the drawing and the figure.
[0035]Drawing 1 is a mimetic diagram showing a 1st embodiment of the fuel cell device concerning this invention.
[0036]The fuel cell device concerning this embodiment the plate-like unit cell (unit cell) 10 which makes a usable area 169-cm^2, for example, Use ten sheets, put in the perpendicular direction, constitute the cell stack 11, and the cell stack 11, For example, while dividing to the cell stack 11a for low-temperature operation, the cell stack 11b for moderate temperature operation, and the cell stack 11c for high temperature operations and electrically connecting, It has composition which passes fuel gas and oxidant gas continuously toward the cell stack 11c for high temperature operations from the cell stack 11a for low-temperature operation among the cell stacks 11a, 11b, and 11c for high temperature operations into each low one. In this embodiment, each operating temperature of the cell stacks 11a, 11b, and 11 for high temperature operations is set as 50 **, 60 **, and 65 ** into low, A steam is beforehand added and humidified into low to the fuel gas and oxidant gas which are supplied to the cell stacks 11a, 11b, and 11c for high temperature operations, and into low, humidity of above-mentioned reactant gas is made high so that the operating temperature of the cell stacks 11a, 11b, and 11c for high temperature operations may be balanced.
[0037]When reactant gas (both fuel gas and oxidant gas) flows toward the cell stack 11c for high temperature operations one by one from the cell stack 11a for low-temperature operation, Since the diffusion rate of as opposed to [a reaction consumption rate (capacity factor) is high at the upstream, and a reaction consumption rate is low at the downstream, and] the anode

electrode side of reactant gas and the cathode terminal side becomes low, in this embodiment. The effective area product of the fuel gas supply groove of the downstream and an oxidizer supply groove (not shown [both]) is relatively made small compared with it of the upstream, and it has the composition of raising the rate of flow of reactant gas and making reaction efficiency equalizing. Both a fuel gas supply groove and an oxidant gas supply groove make a pitch the same, and, specifically, have formed the depth ratio in 4:3:1 into low to the cell stacks 11a, 11b, and 11c for high temperature operations.

[0038]At this embodiment provided with such composition, as a result of being test operation, as for 400 mA/cm^2 and the reaction consumption rate (capacity factor) of fuel gas, 80%, the reaction consumption rate (capacity factor) of oxidant gas became 50%, and cell output operation time of load current density improved in 3000 hours compared with the former.

[0039]In this embodiment, since the cell stack 11 was divided into low to the cell stacks 11a, 11b, and 11c for high temperature operations, Compared with one cell stack which sets an operating temperature constant, average voltage increased 5% like before, and generating the stable cell output with little variation distribution moreover was accepted.

[0040]Thus, in this embodiment, the cell stack 11 is divided into low to each of the cell stacks 11a, 11b, and 11c for high temperature operations, Since reactant gas was made the composition passed from the cell stack 11a for low-temperature operation to continuation toward the cell stack 11c for high temperature operations one by one while carrying out the series connection of the cell stacks 11a, 11b, and 11c for high temperature operations electrically into low [which was divided], The stable cell output can be generated and the reaction consumption rate (capacity factor) of reactant gas can be raised further.

[0041]Namely, into low, to the cell stacks 11a, 11b, and 11c for high temperature operations, one by one, since reactant gas is passed to continuation, For example, even if the unreacted part of reactant gas increases comparatively in the cell stack 11a for low-temperature operation, it can be made to be able to react by the next object for moderate temperature operation or the cell stacks 11b and 11c for high temperature operations, and can be made to consume without the place which leaves reactant gas.

[0042]In this embodiment, since the effective area product of the fuel gas supply groove of the downstream and the oxidant gas supply groove was relatively made small compared with it of the upstream and the rate of flow of reactant gas was raised, equalization of reaction efficiency can be attained and the stable cell output can be generated.

[0043]Therefore, since the cell output stable even if it did not supply reactant gas to each of the cell stacks 11a, 11b, and 11c for high temperature operations superfluously into low can be promoted according to this embodiment, the amount of supply of reactant gas can be lessened compared with the former.

[0044]In this embodiment, since each operating temperature of the cell stacks 11a, 11b, and

11c for high temperature operations was made high one by one in accordance with the flow of reactant gas into low, Since it will be made to evaporate in the object for moderate temperature operation or the cell stacks 11b and 11c for high temperature operations of order with a high operating temperature even if the water of condensation generated increases in number in the case of the reaction of the oxidant gas by the side of the carbon electrodes of the cell stack 11a for low-temperature operation, oxidant gas can be made to react good. Into low, although it may install separately [each of the cell stacks 11a, 11b, and 11c for high temperature operations] independently, since a specific cell stack has possibility of a fault cell output when it installs separately independently, it is preferred to carry out a series connection electrically.
[0045]Drawing 2 is a mimetic diagram showing a 2nd embodiment of the fuel cell device concerning this invention. Identical codes are given to the portion which is the same as the component part of a 1st embodiment, or corresponds.
[0046]The fuel cell device concerning this embodiment like a 1st embodiment the cell stack 11, For example, while dividing into low to the cell stacks 11a, 1b, and 11c for high temperature operations and carrying out the series connection of the cell stacks 11a, 11b, and 11c for high temperature operations electrically into low, The cooling-medium feeding means 12 which supplies a cooling medium, for example, cooling water, succeeding the cell stacks 11a, 11b, and 11c for high temperature operations, for example, cooling water piping, is established into low. The operating temperature of the cell stack 11a for low-temperature operation is determined by the temperature of the cooling medium supplied from the cooling-medium feeding means 12. The operating temperature of the cell stack 11c for high temperature operations measures the temperature of the cooling medium discharged from the cell stack 11c for high temperature operations, and is determined by adjusting the amount of cooling media. The mean temperature of the operating temperature of the cell stack 11a for low-temperature operation and the operating temperature of the cell stack 11c for high temperature operations is used for the operating temperature of the cell stack 11b for moderate temperature operation.
[0047]Thus, in this embodiment, the cooling-medium feeding means 12 which continues and supplies a cooling medium to the cell stacks 11a, 11b, and 11c for high temperature operations is established into low, Since much more temperature inclination-ization of the cell stacks 11a, 11b, and 11c for high temperature operations was attained into low, When making oxidant gas react temporarily by the cathode terminal side of the cell stack 11a for low-temperature operation, Even if the water of condensation generated increases in number, promotion of evaporation can be made to be able to ensure by the next object for moderate temperature operation or the cell stacks 11b and 11c for high temperature operations, and the cell output which raised much more reaction of oxidant gas and was stabilized can be generated.
[0048]Drawing 3 is a mimetic diagram showing a 3rd embodiment of the fuel cell device

concerning this invention. Identical codes are given to the portion which is the same as the component part of a 1st embodiment, or corresponds.

[0049]The inside of low [which showed the fuel cell device concerning this embodiment by a 1st embodiment], inside, and the cell stacks 11a, 11b, and 11c for high temperature operations, While dividing further the cell stack 11a for low-temperature operation into low to each of sub cell stack $11a_1$ for high temperature operations, $11a_2$, and $11a_3$, The flow direction and uniform direction of reactant gas (both fuel gas and oxidant gas) are made to carry out the series connection of sub cell stack $11a_1$ for high temperature operations, $11a_2$, and the $11a_3$ into low. Inside the cell stacks 11b and 11c for high temperature operations like ****, It is divided by sub cell stack $11b_1$ for low-temperature operation, $11c_1$, sub cell stack $11b_2$ for moderate temperature operation, $11c_2$, sub cell stack $11b_3$ for high temperature operations, and $11c_3$.

[0050]Generally, the cell stack 11 has cell output density in the tendency which becomes high to the thing compared with the outlet side in which the reaction consumption rate (capacity factor) of reactant gas is [the entrance side] lower, when the independent cell 10 is taken for an example.

[0051]In this embodiment, are what noted such a point, and into low to every cell stack 11a and 11b for high temperature operations, and 11c. It divides finely into low to sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --.

[0052]Low [which was divided into low in this embodiment to every cell stack 11a and 11b for high temperature operations, and 11c], Inside, The fuel gas supply groove which supplies reactant gas (both fuel gas and oxidant gas) to sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --. And compared with the upstream, the downstream is relatively made small for the effective area product of an oxidant gas supply groove (not shown [both]), and it has the composition of raising the fluid of reactant gas and making reaction efficiency equalizing. Like a 1st embodiment, make a pitch the same and specifically [both] the depth ratio, It has formed in 4:3:1 into low to sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --.

[0053]Thus, in this embodiment into low to every cell stack 11a and 11b for high temperature operations, and 11c. Since it divided finely into low with sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --. The stable cell output without the unevenness from the cell stacks 11a, 11b, and 11c for high temperature operations can be generated into low.

[0054]In this embodiment, into low to every cell stack 11a and 11b for high temperature

operations, and 11c. Since it divided finely into low with sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --, In the case of the reaction of oxidant gas, the water of condensation generated can be evaporated further and the reaction of oxidant gas can be promoted good.

[0055]In this embodiment, since the effective area product of the fuel gas supply groove of the downstream and the oxidant gas supply groove was relatively made small compared with it of the upstream and the rate of flow of reactant gas was raised, much more equalization of reaction high rate can be attained, and the stable cell output can be generated.

[0056]Drawing 4 is a mimetic diagram showing a 4th embodiment of the fuel cell device concerning this invention. Identical codes are given to the component part, the identical parts, or the corresponding portion of a 1st embodiment.

[0057]Like a 1st embodiment, while dividing the fuel cell device concerning this embodiment, for example into low to the cell stacks 11a, 11b, and 11c for high temperature operations, the cell stack 11, The reactant gas currently supplied to the cell stacks 11b and 11c for high temperature operations is made inside the composition which supplies an opposite direction one by one from the cell stack 11a for low-temperature operation after the operation-time progress which was able to be defined beforehand. The valve (not shown) installed in piping is specifically changed, and it is carried out by passing reactant gas to the flow direction and opposite direction of a graphic display. The operating method passed to an opposite direction is applied also to a 3rd embodiment shown by drawing 3 after the operation-time progress which was able to define reactant gas beforehand.

[0058]Thus, in this embodiment, since reactant gas was made the composition passed to an opposite direction after the operation-time progress which was able to be defined beforehand, the fall of the battery characteristic of the cell stacks 11a, 11b, and 11c for high temperature operations can be low suppressed into low, and generating of the stable cell output can be maintained for a long time.

[0059]Drawing 5 is a mimetic diagram showing a 5th embodiment of the fuel cell device concerning this invention. Identical codes are given to the portion which is the same as the component part of a 1st embodiment, a 2nd embodiment, and a 3rd embodiment, or corresponds.

[0060]The fuel cell device concerning this embodiment is what combined a 2nd embodiment and a 3rd embodiment with a 1st embodiment, Into low, to every cell stack 11a and 11b for high temperature operations, and 11c Low, inside, While dividing sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and --, the cooling feeding means 12 which pours a cooling medium is formed in the flow direction and uniform direction of reactant gas.

[0061]In this embodiment, thus, low, inside, Establish sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and the cooling-medium feeding means 12 of -- that continues and supplies a cooling medium to the flow direction and uniform direction of reactant gas, and Low, inside, Since sub cell stack $11a_1$ for high temperature operations, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and much more temperature inclination-ization of -- were attained, Evaporation of the water of condensation of each sub cell stack $11a_1$, $11b_1$, $11c_1$, $11a_2$, $11b_2$, $11c_2$, and -- generated by the carbon-electrodes side can be promoted further, and the stable cell output can be generated.
[0062]Drawing 6 is a schematic diagram showing the embodiment of the separator applied to the fuel cell device concerning this invention.
[0063]While the separator 13 concerning this embodiment forms two or more reactant gas supply grooves 14 which supply reactant gas in accordance with the perpendicular direction, The entrance head 15 provided with the inlet manifold 15a and the exit header 16 provided with the outlet manifolds 16a are formed in the both ends of the reactant gas supply groove 14.

[0064]Thus, in this embodiment, since the inlet header 15 and the exit header 16 are formed in the both ends of the reactant gas supply groove 14 of the separator 13 and more reactant gas is supplied to them, a still higher cell output can be generated compared with the former.
[0065]In this embodiment, since the both ends of the reactant gas supply groove 14 were equipped with the inlet header 15 and the exit header 16, More water of condensation generated from reactant gas can be processed, and without making the structure of the reactant gas supply groove 14, and shape complicate like before, the production man day time can be lessened and it can contribute to cost reduction. Since this embodiment equips the pars-basilaris-ossis-occipitalis side of the inlet header 15 and the exit header 16 with the manifolds 15a and 16a of the entrance and the exit, it can change the feeding-and-discarding exit of reactant gas freely.
[0066]Drawing 7 is an outline control system figure showing the embodiment which controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention. Identical codes are given to the component part and identical parts of a 1st embodiment.
[0067]The cell stack 11 concerning this embodiment has the composition of having made into 30 sheets the plate-like unit cell (unit cell) 10 which makes a usable area 169-cm^2, for example, and having accumulated it in the perpendicular direction.
[0068]This cell stack 11 is provided with the humidifiers 17a and 17b which make that entrance side humidify fuel gas and oxidant gas, and the dew point recorder 18 which measures the

humidity of oxidant gas to that outlet side. A hygrometer may be sufficient as the dew point recorder 18.

[0069]In order that the cell stack 11 may adjust the operating temperature in the vessel, It has composition provided with the cooling-medium feed unit 22 which combined the condensator 19, the tank 20, and the circulating pump 21 which supply a cooling medium, for example, cooling water, and the control calculation part 23 which gives a control signal to the condensator 19 and the circulating pump 21.

[0070]When the operating temperature in a vessel is set, for example as 80 ** now in the cell stack 11 provided with such composition, When the temperature which the operating temperature in a vessel measured with the dew point recorder 18 rather than 80 ** in the circumference of lower becomes 78 ** or less, the control calculation part 23, It calculates based on the operating temperature in a vessel, and the measurement temperature of the dew point recorder 18, the operation signal is given to the condensator 19 and the circulating pump 21, and the condensator 19 and the circulating pump 21 are made to drive. When it becomes higher than the operation operating temperature in a vessel, the control calculation part 23 gives the operation signal to the condensator 19 and the circulating pump 21, and stops the drive of the condensator 19 and the circulating pump 21.

[0071]thus -- forming the cooling-medium feed unit 22 and the control calculation part 23 in the cell stack 11 in this embodiment -- vessel inside installation -- a law -- to an operating temperature at the time of lower ******. Since evaporation of the water of condensation generated within a vessel was promoted when the water of condensation generated within a vessel was promoted, on the contrary it exceeded to the setting-out operating temperature in a vessel, the cell output generated from the cell stack 11 can be further heightened compared with the former. Incidentally, according to the experiment, sag speed was able to be made low 1/3 or less compared with the conventional operating-temperature regularity.

[0072]Drawing 8 is a control system figure showing the 1st modification of the embodiment shown in drawing 7 that controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention.

[0073]While making it the same as that of the composition of the embodiment shown by drawing 7 in this example, Attach the measure resistance device 24 which measures the internal resistance of the unit cell 10 to the cell stack 11, it is made to calculate in the control calculation part 23 based on the resistance signal from the measure resistance device 24, and a vessel internal temperature degree signal, and is made to drive the cooling-medium feed unit 22.

[0074]When the measure resistance device 24 sets the operating temperature in a vessel, for example as 80 **. If the internal resistance value of the unit cell 10 becomes for example, more than 90-ohmcm^2. If the cooling-medium feed unit 22 is made to drive, the operating

temperature of the cell stack 11 is reduced and it becomes below 90-ohmcm^2 conversely, the drive of the cooling-medium feed unit 22 is stopped, and it has composition which raises the operating temperature of the cell stack 11.

[0075]Therefore, according to this example, the cell output of the water of condensation generated in a vessel generated from the cell stack 11 since the operating temperature of the cell stack 11 is somewhat controllable according to quantity can be further heightened compared with the former.

[0076]Although the measure resistance device 24 was attached to the cell stack 11 in this example, Load current 25 [a total of] may be attached to the cell stack 11, it may be made to calculate in the control calculation part 23 based on the current signal from load current 25 [a total of], the signal from the humidifiers 17a and 17b, and the vessel internal temperature degree signal from the thermometer 26, and the cooling-medium feed unit 22 may be made to drive, as shown in drawing 9.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The lineblock diagram showing a 1st embodiment of the fuel cell device concerning this invention.
[Drawing 2]The mimetic diagram showing a 2nd embodiment of the fuel cell device concerning this invention.
[Drawing 3]The mimetic diagram showing a 3rd embodiment of the fuel cell device concerning this invention.
[Drawing 4]The mimetic diagram showing a 4th embodiment of the fuel cell device concerning this invention.
[Drawing 5]The mimetic diagram showing a 5th embodiment of the fuel cell device concerning this invention.
[Drawing 6]The schematic diagram showing the embodiment of the separator applied to the fuel cell device concerning this invention.
[Drawing 7]The outline control system figure showing the embodiment which controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention.
[Drawing 8]The outline control system figure showing the 1st modification in the embodiment which controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention.
[Drawing 9]The outline control system figure showing the 2nd modification in the embodiment which controls the operating temperature of the cell stack applied to the fuel cell device concerning this invention.
[Drawing 10]The mimetic diagram showing the unit cell in the conventional fuel cell device.
[Description of Notations]
1 Solid polyelectrolyte membrane
2 Anode electrode

2a Anode catalyst layer
2b Anode porous carbon plate
3 Cathode terminal
3a Cathode catalyst bed
3b Cathode porous carbon plate
4 and 10 Unit cell
5a Fuel gas supply groove
5b Oxidant gas supply groove
6 and 7 Separator
6a and 7a Partition
8 Cell stack
10 Unit cell
11 Cell stack
11a The cell stack for low-temperature operation
$11a_1$, $11b_1$, the sub cell stack for $11c_1$ low-temperature operation
11b The cell stack for moderate temperature operation
$11a_2$, $11b_2$, the sub cell stack for $11c_2$ moderate temperature operation
11c The cell stack for high temperature operations
$11a_3$, $11b_3$, the sub cell stack for $11c_3$ high temperature operations
12 Cooling water supply means
13 Separator
14 Reactant gas supply groove
15 Inlet header
15a Inlet manifold
16 Exit header
16a Outlet manifolds
17a and 17b Humidifier
18 Dew point recorder
19 Condensator
20 Tank
21 Circulating pump
22 Cooling-medium feed unit
23 Control calculation part
24 Measure resistance device
25 Load current meter
26 Thermometer

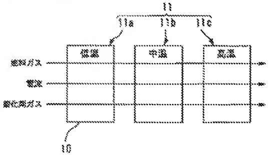
[Translation done.]

* NOTICES *

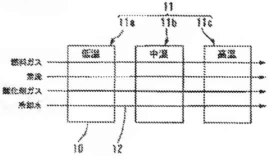
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

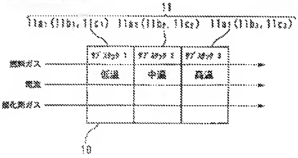
[Drawing 1]



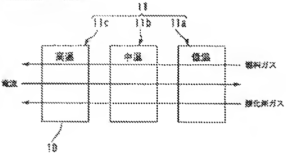
[Drawing 2]



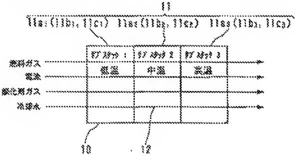
[Drawing 3]



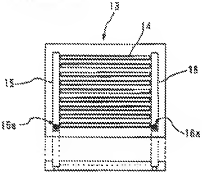
[Drawing 4]



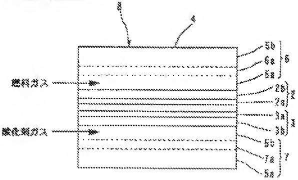
[Drawing 5]



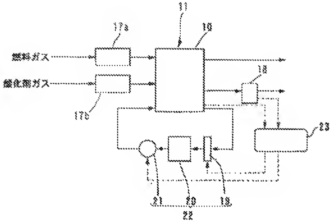
[Drawing 6]



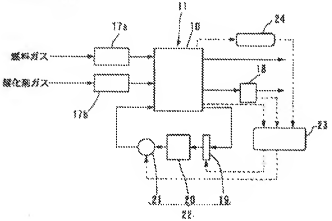
[Drawing 10]



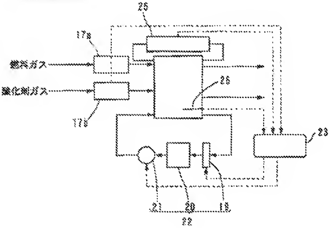
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]